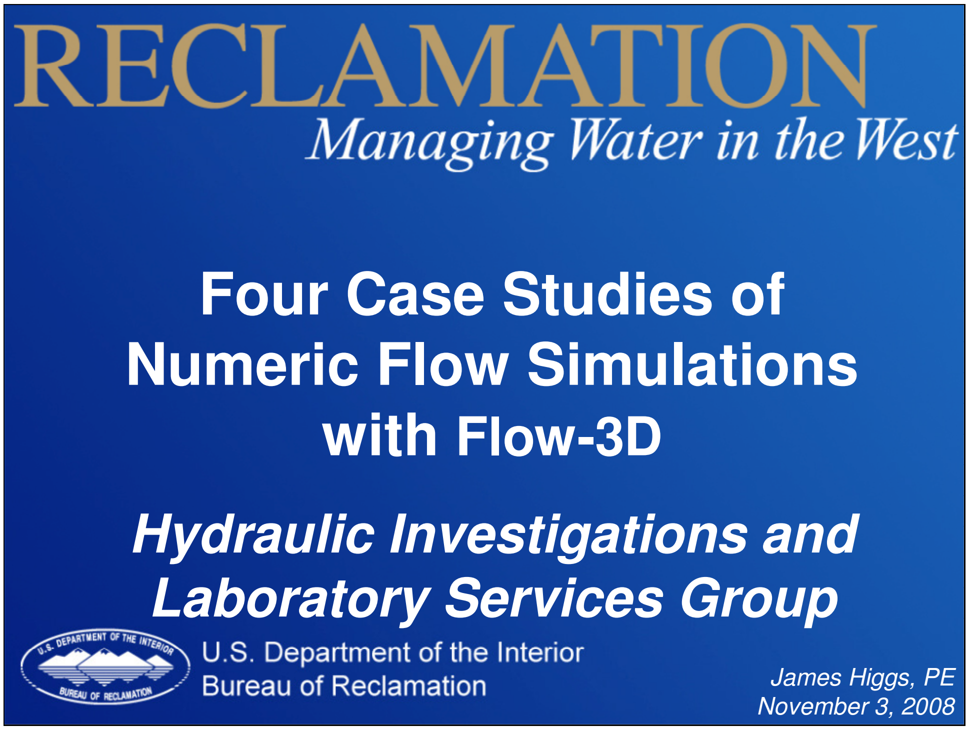


I am Jim Higgs, I primarily do computer modeling of water flows for our group, the Hydraulic Investigations and Laboratory Services Group.

The purpose of this presentation is to display group capabilities in regards to computer simulations that may be applied to your environmental concerns.

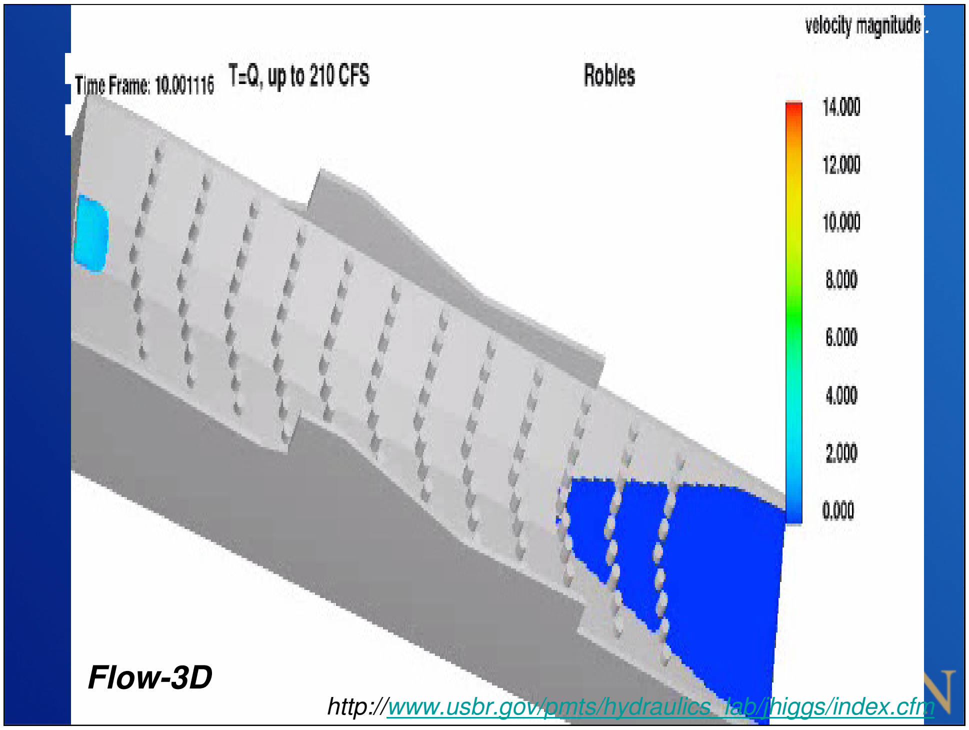
For additional information, see

http://www.usbr.gov/pmts/hydraulics_lab/jhiggs/index.cfm

Flow-3D

- By Flow Science, Inc. in Santa Fe, New Mexico
- **C**omputational **F**luid **D**ynamics (uses the full Navier-Stokes Equations)
- One, two, or three spatial dimensions
- Finite volume (finite difference)
- Structured multi-block mesh
- Free surface or confined
- Transient flow

RECLAMATION



This is a proposed fishway for Robles dam http://www.usbr.gov/pmts/hydraulics_lab/jhiggs/index.cfm , for upstream fish passage. While this animation is running, I will describe the program that I used to simulate it.

Flow-3D was used to simulate this fishway. Flow-3D, developed by Flow Science, Inc. in Santa Fe, New Mexico.

It is a Computational Fluid Dynamics program, also known as CFD. As a CFD program, it uses the full Navier-Stokes Equations, Navier-Stokes Equations fully describes motion of a single fluid. Flow-3D rarely need calibration or verification, unless a new feature is used, like air entrainment.

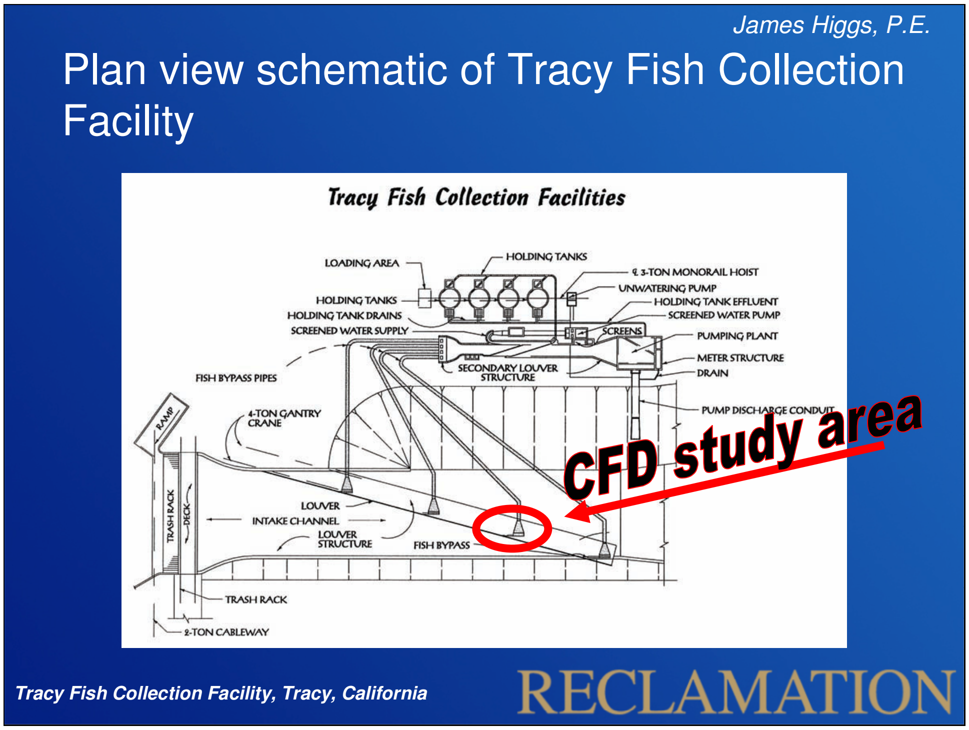
Flow-3d can model one, two, or three spatial dimensions. It is based on the finite volume/finite difference approach. It uses a structured multi-block meshes. It can simulate a free surface or confined flow. It simulates transient flows, like the one shown here, which can be run until steady state is achieved, which this simulation reaches by 300 seconds.

I created this Proposed Robles simulation for Brent Mefford from our group. As you can see, inflow increases with time, so the inflow in cubic feet per second is equal to the time in seconds, up to 210 cubic feet per second. There after the inflow is steady. So at 100 seconds, the inflow is 100 cubic feet per second. The animation plays about 4 times faster than reality.

The weirs are about 10 feet apart with one foot drop in elevation between them. Brent used this information to look for resting places, upstream passage locations, and to calculate the resident time of water between each weir. Residence time is the time for the total volume in that section to be replaced. Resident time is the volume divided by the discharge, and he was looking for a value above 4 seconds.

Our group has been involved with several projects of the Tracy Fish Collection Facility, in Tracy, California. For this presentation I thought I would share my small contribution to one of those projects.

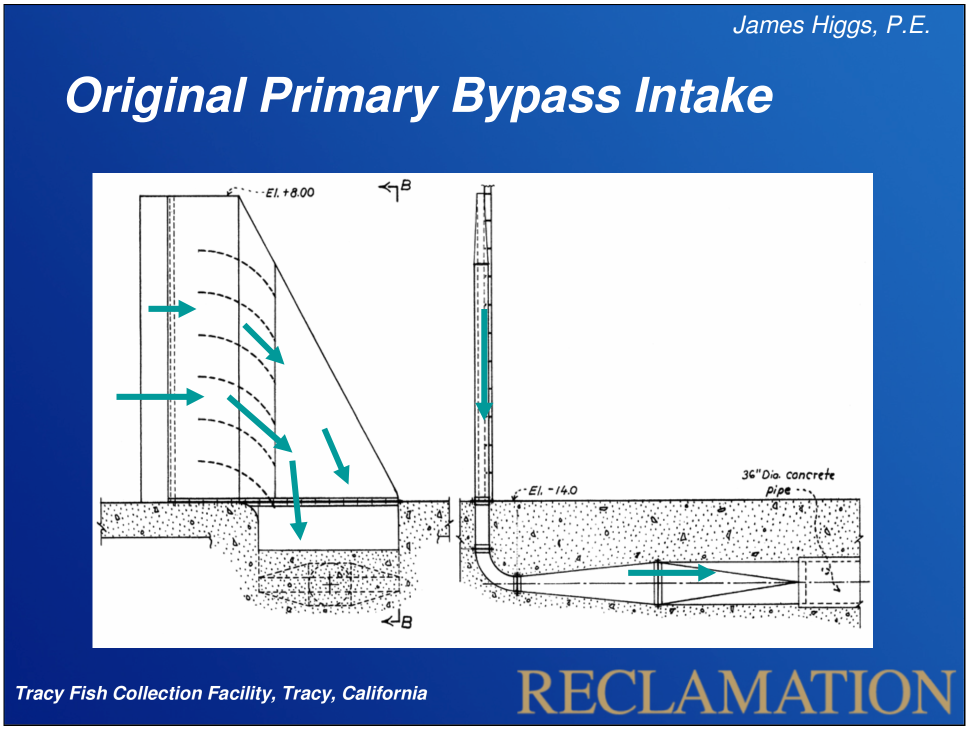
Here you can see where the water flows in past the trashrack, is restrained by the training wall, then while water flows through the louvers and fish bypass. The goal is to get as many fish into and through the by pass as possible.



This is a plan view of they facility’s layout.

For those unfamiliar with the layout, does take time to understand. From the previous picture you may recognize the trashrack upstream of the triangluar intake channel, and the louvers.

I simulated the flow conditions in one bypass like the one pointed out here.



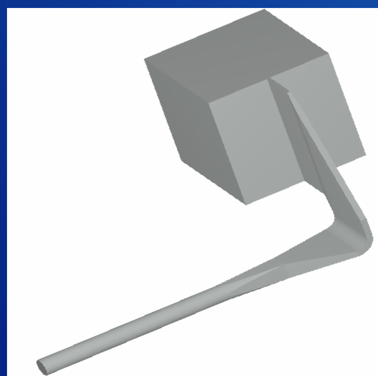
This shows the flows directions through two profiles of the original fish bypass, side view on the left, and upstream view on the right. It is difficult to understand, the next slide has a 3D view of it.

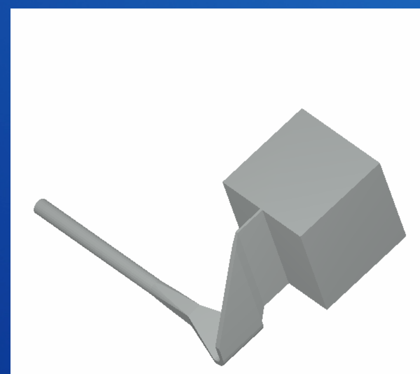
As I have displayed here, the inflow velocity at the bottom was much higher at than the top, which was not optimal for fish attraction.

As it turned out, the existing bypass required replacement.

James Higgs, P.E.

Model Study of a Proposed Primary Bypass Intake

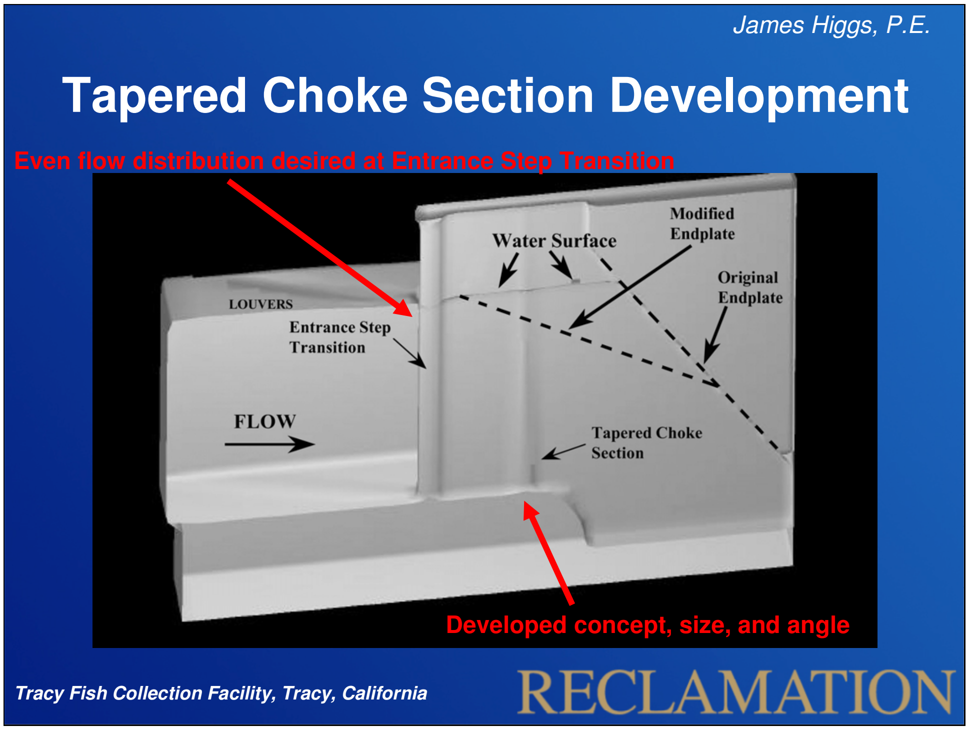




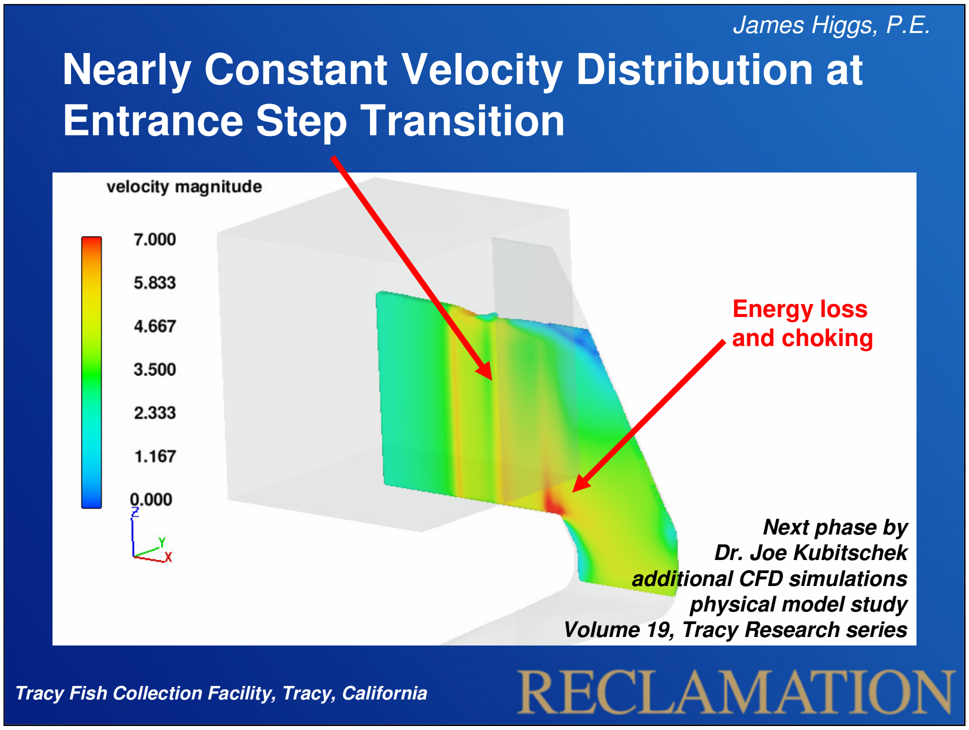
Tracy Fish Collection Facility, Tracy, California

RECLAMATION

This is what I modeled for the proposed replacement. It is every similar in design, but lacks the guide vanes that the original had. The block upstream helped model the approach to the bypass, but not part of the bypass itself.



This is a cross section of the proposed bypass. Because the flow was too high at the bottom of the bypass, I came up with the idea of a tapered choke section that you can see here. You can picture it as a pipe cut at an angle along it's length. It creates a narrow opening at the bottom which causes more choking and energy loss at the bottom, which created better velocity distribution at the entrance.



This displays colored total velocity contours in the bypass. As you can see, velocity distribution at the entrance was nearly constant. In the next phase of this studies, Dr. Joe Kubitschek performed additional CFD simulations to take into account more of the approach conditions and performed a physical model study, for which he reported the results in **Volume 19** in the Tracy Research series.

It would be impossible recognize all of the contributors from our group for this part of the Tracy Studies, but I would alike to mention Brent Mefford's and the late Perry Johnson's contributions were invaluable, and Connie Demoyer's field measurement confirming flow conditions.

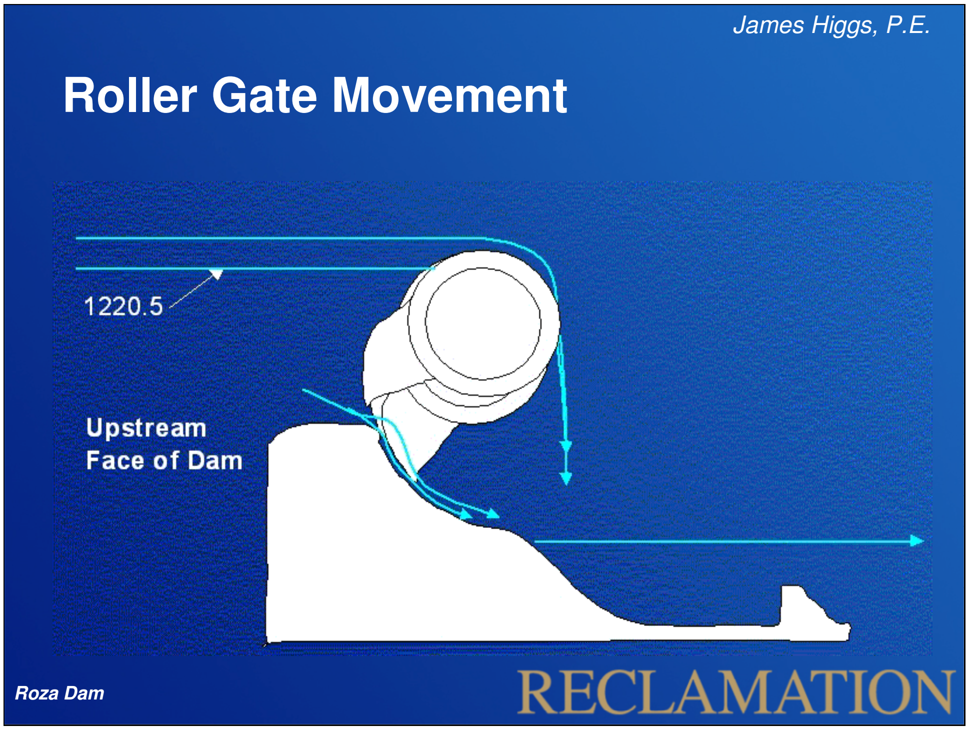
Before I move on to talking about studies at Roza Dam, are there any questions?

Roza Diversion Dam located 10 miles north of Yakima, in south-central Washington, and diverts water from the Yakima River. The dam is a concrete weir, movable crest structure, 486 feet long at the crest, 67 feet high, and contains 21,700 cubic yards of concrete.

The key reason Warren Frizell and I are involved with this project is for the downstream passage of juvenile smolt.

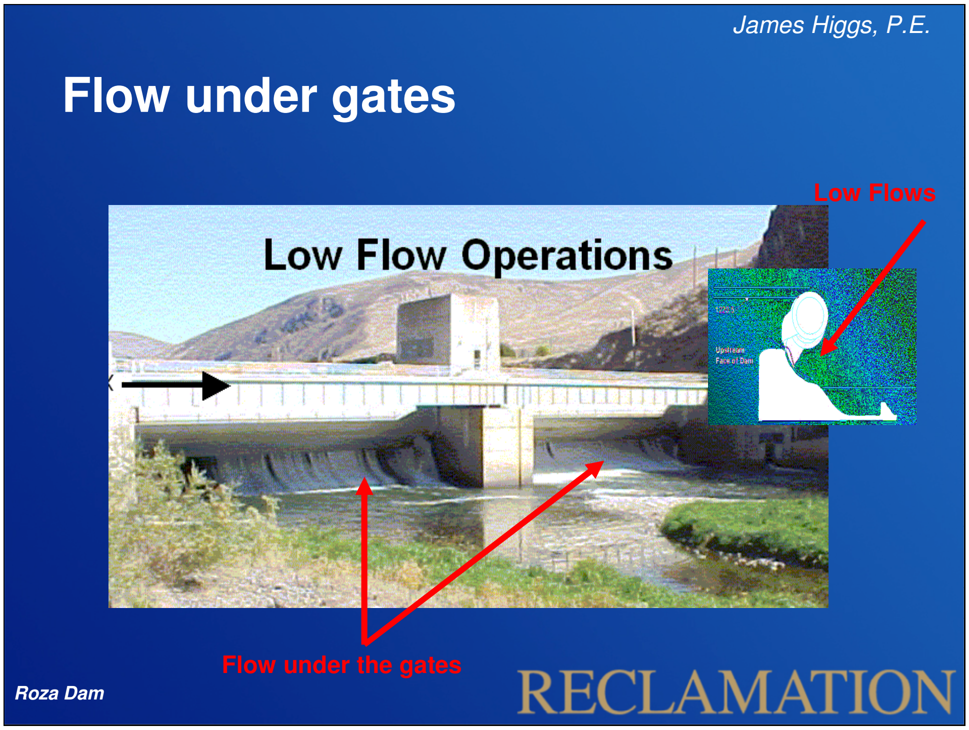
Key components of this study are the fishway for upstream passage, the fish bypass for downstream passage, the power canal and intake structure, and the roller gates – which I will describe in more detail in a minute.

The purpose of this study is to promote downstream fish passage through the fish bypass rather than under the roller gates.

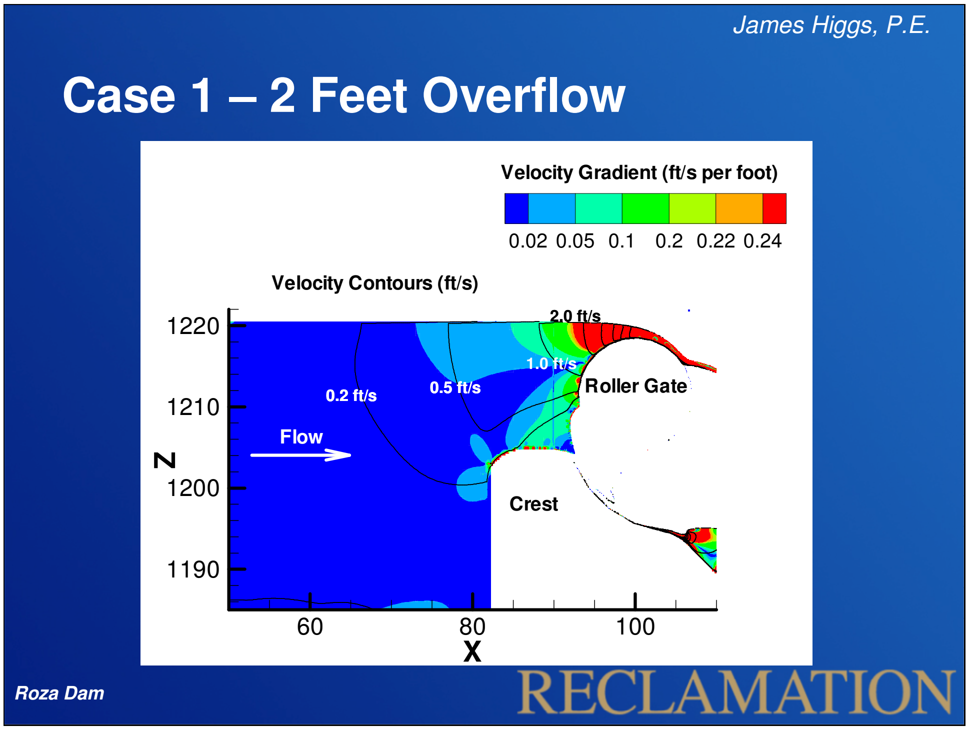


The roller gate is rather complex, because it can move up and down and at the same time it can rotate to control or shut off flow underneath.

This shows flow going over the gate.



This is looking upstream looking at low flows under the roller gates.



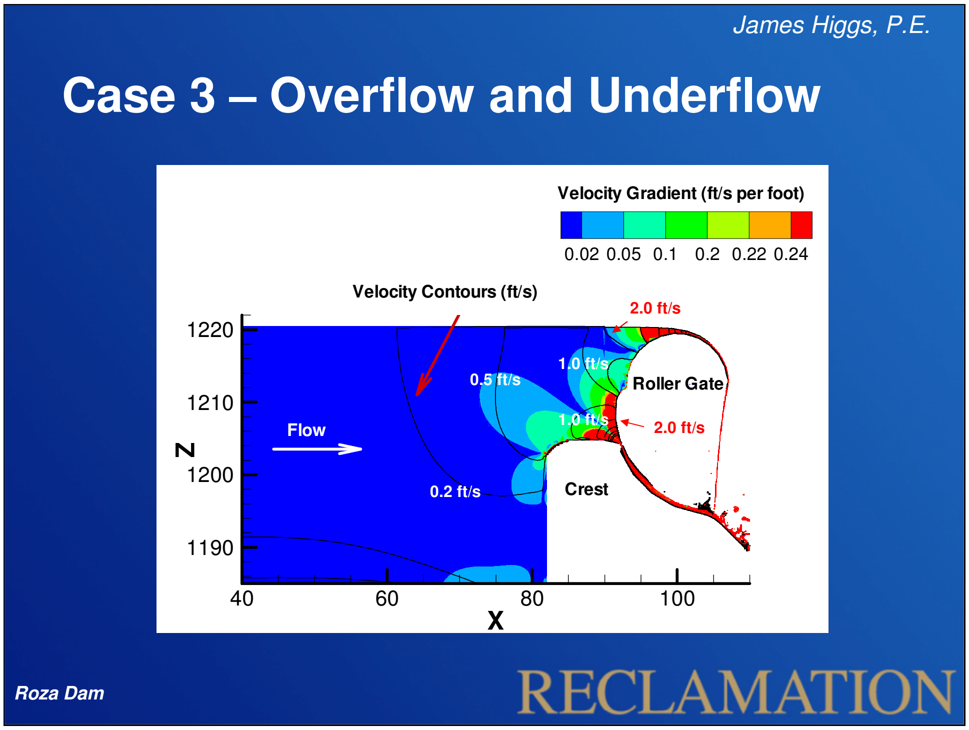
One part of the study looked at approach velocities and velocity gradient using 2D simulations. Notice the location of the crest and roller gates.

Velocity gradients are shown in color contours, and are measured in ft/sec/ft, or just per second. We are considering a velocity gradient of 0.2 ft/sec/ft as avoidance criteria, where the juvenile smolt will try to avoid flows that exceed 0.2 ft/sec/ft.

[You may notice that velocity gradients are the inverse of residence time that we discussed during the Robles. So the residence time that the smolt would try to avoid is anything below 5 seconds.]

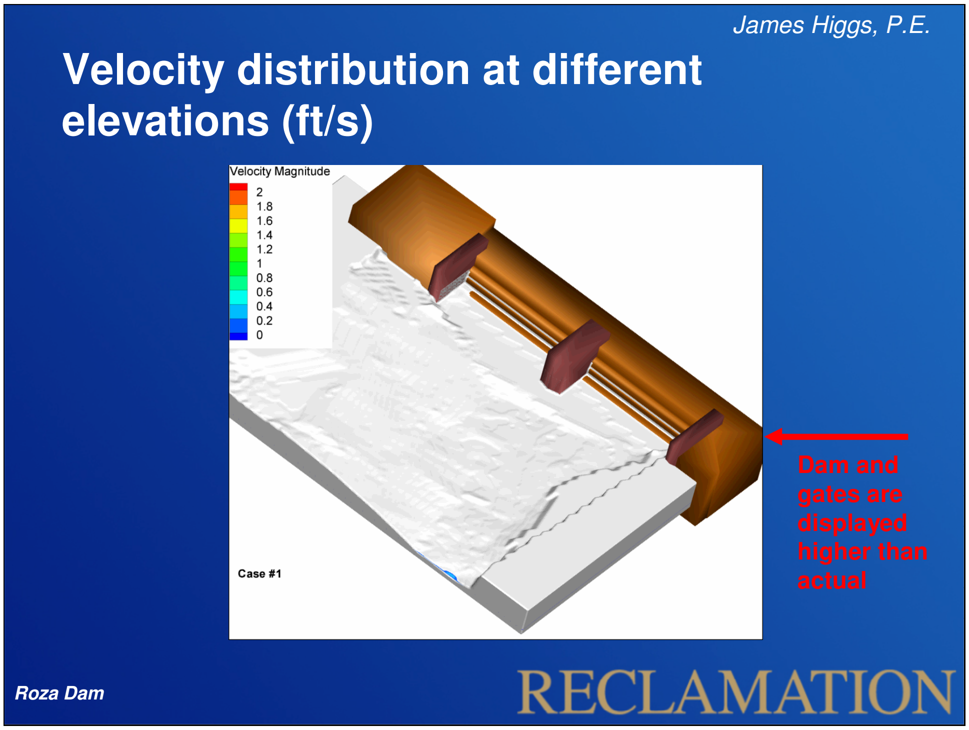
However, the smolt may be captured by velocities above 2 feet/second. So if we want the smolt to go over the gate, we would want the 2 feet/second capture velocity to occur upstream of the 0.2/second avoidance velocity gradient shown in red.

Since the captured velocity and avoidance velocity gradient are so close, it is difficult to predict capture efficiency.



In this case there is flow underneath the gate, as well as above. We do not want the smolt to go under the gate. Notice that for the most part, the 2 feet/second capture velocity occurs downstream of the 0.2/second avoidance velocity gradient shown in orange. So the smolt will tend to avoid this region.

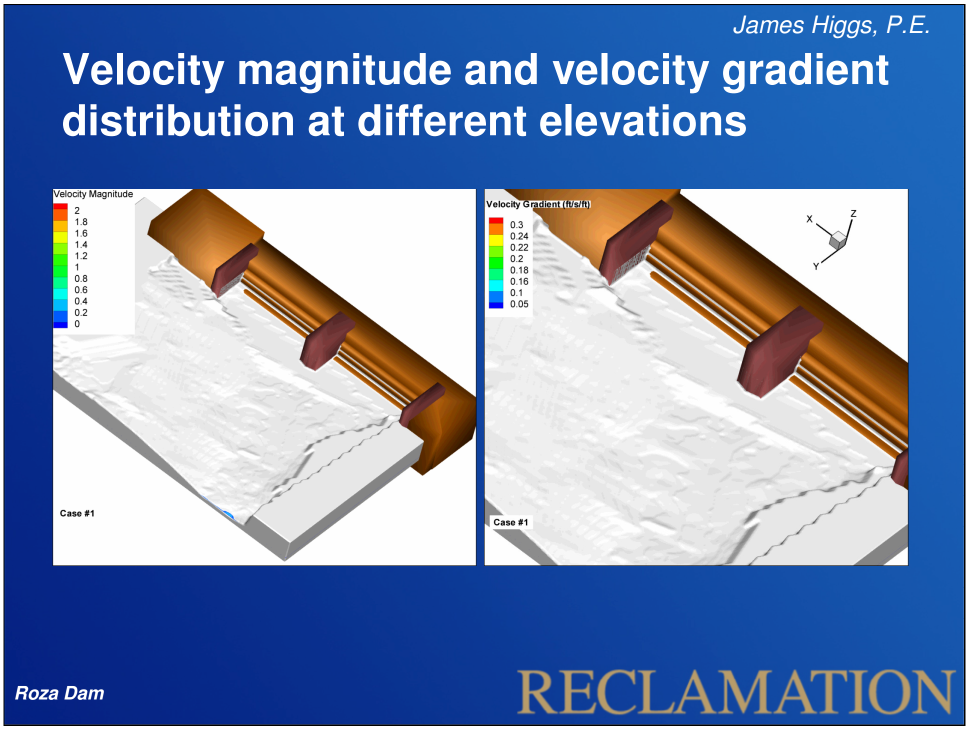
I also looked at 3 dimensional effects of installing Obermeyer gates on the top of the roller gates, which can be used to control the withdrawal zones.



This animation is looking downstream at Roza dam for a historically typical operation. Note that the model displays the and gates higher than actual. This displays only 300 feet upstream of the dam, where the actual simulation extended 1,600 feet upstream to investigate far field effects of the bend and power canal withdrawals

This simulation used “sink” components to simulate the outflow.   This saved time when compared to actually modeling the outflow, which would have required millions additional cells to model the two inch gap under the gate, and the 1 or 2 feet of over flow.

In this animation it is easy to detect flow under the west gate, over the west gate, the low fish bypass, and the higher fishway.

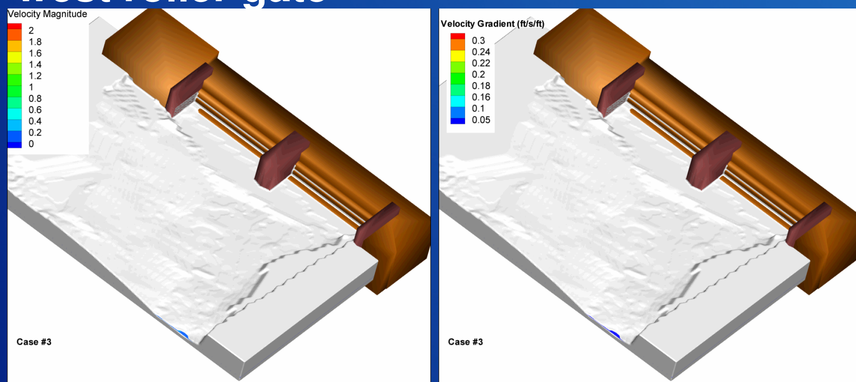


This animation displays the velocity magnitudes and velocity gradient at various elevation for a steady state flow. The animation on the left is the same as the one in the previous slide. Note how the 3 dimensional approach has a minor effect on the flow conditions near the roller gate.

Also note where the capture velocity shown in red on the right and compare that to the avoidance velocity gradient in green on the right.

Velocity magnitudes and velocity gradient distribution at different elevations for flow over west half of the west roller gate

James Higgs, P.E.



Roza Dam

RECLAMATION

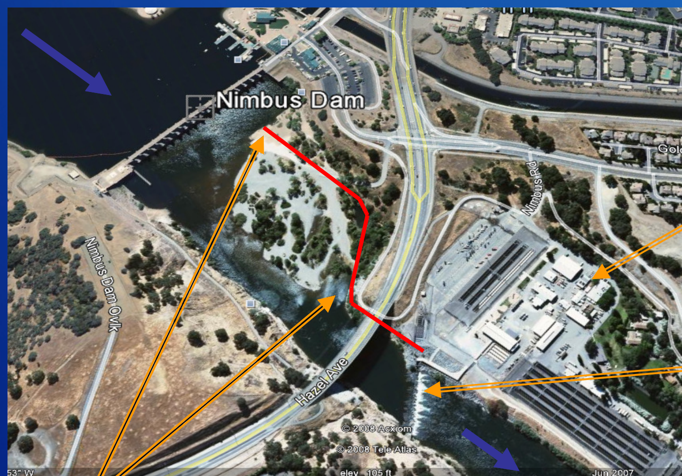
This animation displays flow under the west gate, and flow over the west half of the west gate being controlled by Obermeyer gates.

Considering how nearly uniform the approach conditions are, the 2 dimensional studies may be enough, or perhaps a sectional study of flow conditions that model flow 10 feet to each side of the edge of the Obermeyer gate.

Any questions about this study or modeling approach before we move on to the last case study?

James Higgs, P.E.

Nimbus Dam Proposed Fishway



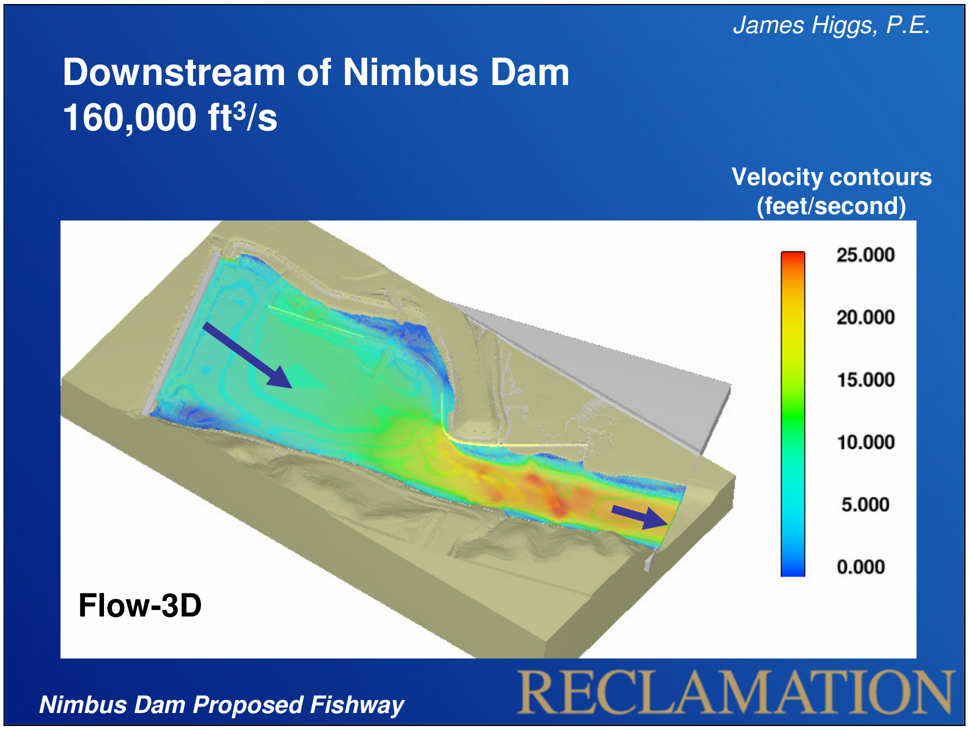
Nimbus fish facilities

Weir to be removed

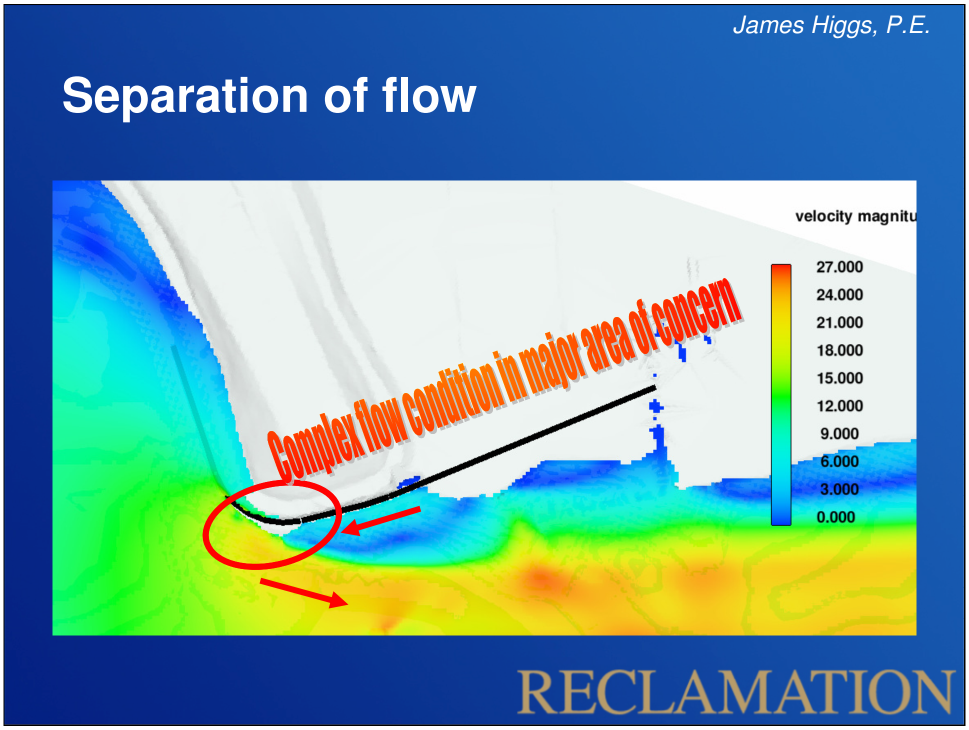
Water Surface Elevation and erosion concerns

RECLAMATION

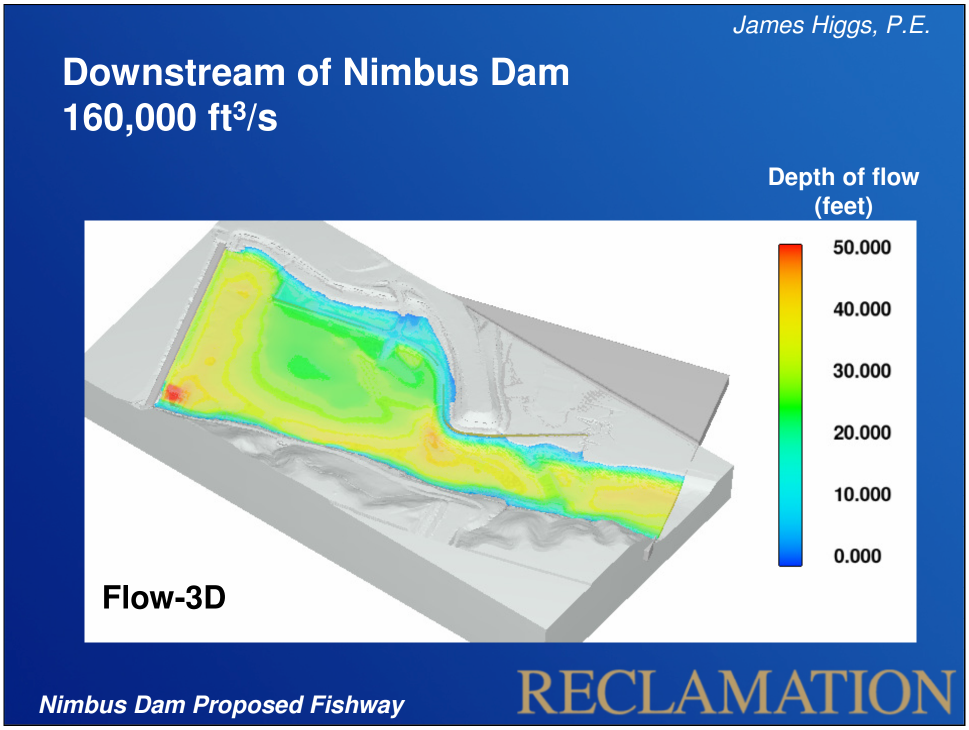
Due to extensive maintenance on the fish barrier weir downstream of Nimbus dam, they have proposed to remove the weir and put in a longer fishway shown in red. Kathy Frizell is the lead for our group on this project, and I have been working with her and the waterways group at considering various water surface elevation and erosion concerns of the embankment supporting the fishway.



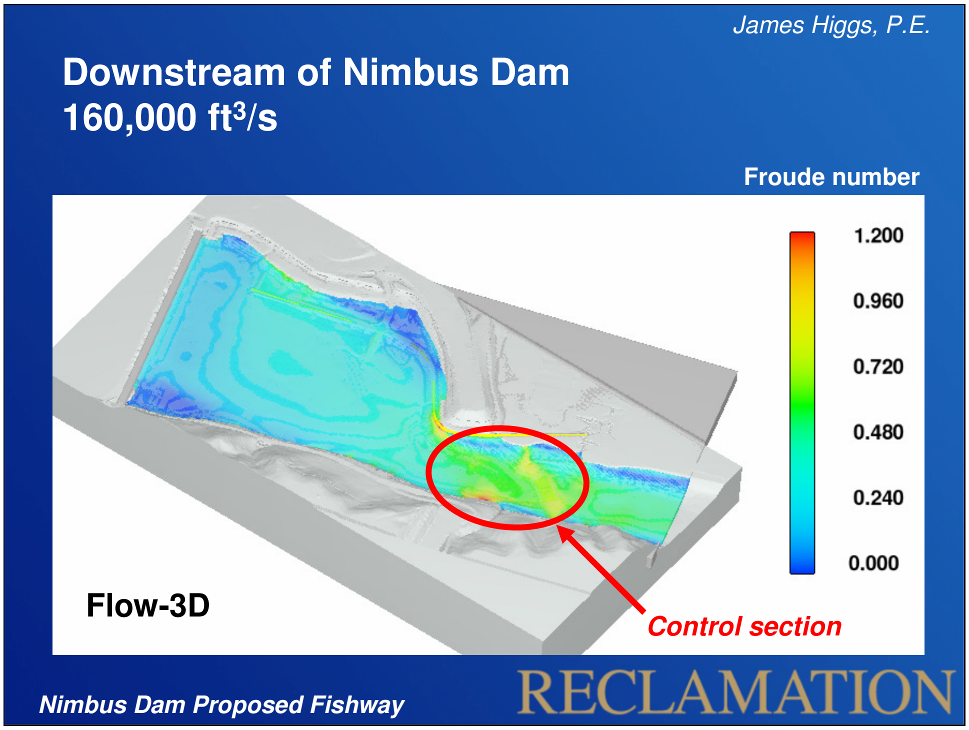
This slide displays the future in-bank discharge capacity of the American River immediately downstream of Nimbus Dam. Notice the contraction of the flow under the bridge, and high velocities at the edge of the fishway embankment upstream.



The separation of flow occurs in one of the area of concern for erosion. The area has highly 3 dimensional conditions.



This slide shows flow depth.

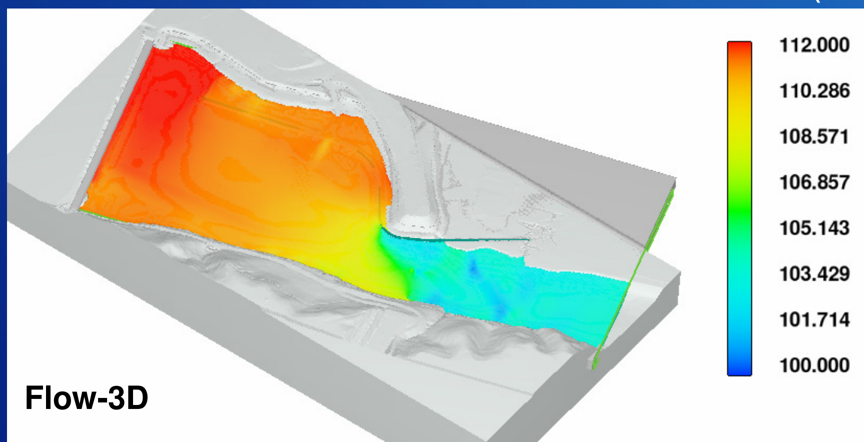


This slide shows Froude number. A Froude number of 1 or higher means downstream conditions will not effect conditions upstream. With a section over the removed weir that has a Froude number around 0.8, the upstream conditions will be insensitive to downstream conditions.

James Higgs, P.E.

Downstream of Nimbus Dam
160,000 ft^3/s

Water surface elevation (feet)

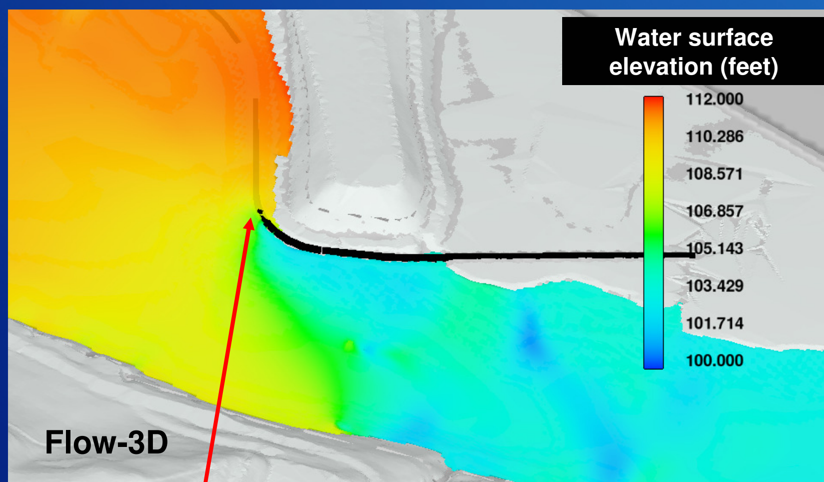


Nimbus Dam Proposed Fishway

RECLAMATION

James Higgs, P.E.

Downstream of Nimbus Dam
160,000 ft^3/s

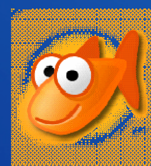
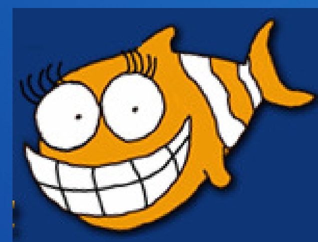


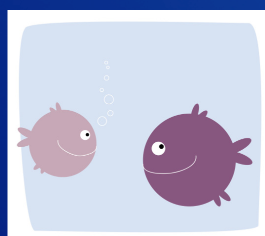
Elevation from 112 feet to 104 feet over 20 feet length ➔ Rapidly varied flow

RECLAMATION

James Higgs, P.E.

Smile, this is the last slide



Questions?

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